1. Introduction to AI
- What is Artificial Intelligence?
- History and evolution of AI
- Types of AI: Narrow AI, General AI, Super AI
- AI vs Machine Learning vs Deep Learning
- Real-world applications and impact

2. Mathematical Foundations
- Linear algebra essentials
- Probability and statistics
- Calculus for optimization
- Information theory basics

3. Machine Learning Fundamentals
- Supervised vs unsupervised vs reinforcement learning
- Training, validation, and test sets
- Overfitting and underfitting
- Bias-variance tradeoff
- Cross-validation techniques

4. Classical Machine Learning Algorithms
- Linear and logistic regression
- Decision trees and random forests
- Support Vector Machines (SVM)
- k-Nearest Neighbors (k-NN)
- Clustering algorithms (k-means, hierarchical)
- Dimensionality reduction (PCA, t-SNE)

5. Neural Networks and Deep Learning
- Perceptron and multilayer perceptron's
- Backpropagation algorithm
- Activation functions
- Optimization algorithms (SGD, Adam, RMSprop)
- Regularization techniques (dropout, batch normalization)

6. Deep Learning Architectures
- Convolutional Neural Networks (CNNs)
- Recurrent Neural Networks (RNNs)
- Long Short-Term Memory (LSTM) and GRU
- Autoencoders
- Generative Adversarial Networks (GANs)

7. Natural Language Processing
- Text preprocessing and tokenization
- Word embeddings (Word2Vec, GloVe)
- Sequence-to-sequence models
- Attention mechanisms
- Transformer architecture
- Large Language Models (GPT, BERT)

8. Computer Vision
- Image preprocessing and augmentation
- Object detection and recognition
- Image segmentation
- Face recognition
- Video analysis

9. Reinforcement Learning
- Markov Decision Processes
- Q-learning
- Deep Q-Networks (DQN)
- Policy gradient methods
- Actor-critic algorithms

10. AI Tools and Frameworks
- Python libraries (NumPy, Pandas, Scikit-learn)
- Deep learning frameworks (TensorFlow, PyTorch)
- Cloud platforms for AI (AWS, Google Cloud, Azure)
- MLOps basics

11. Generative AI, Tools and frameworks
- AI Architecture and Ethical AI
- Generative AI use cases and architecture
- AI Implementation and monitoring platforms and tools

12. AI Challenges and future
- Current AI challenges
- Artificial Super intelligence
- Quantum computing and its role in AGI and ASI

About ME

Trying to make this world a better place to live

AMBASSADOR

Gartner
Peer Community

COSCUP
開 源 人 年 會

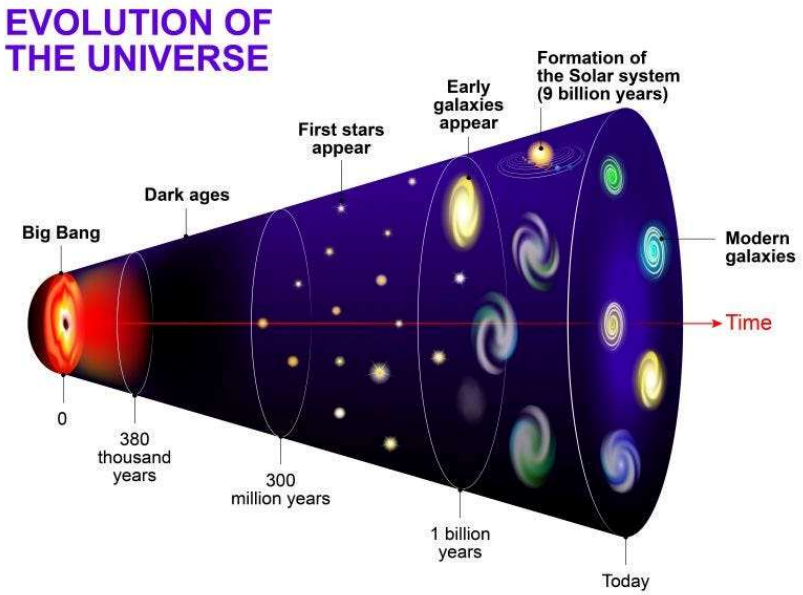
AI Simplified

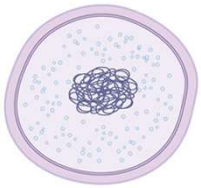
AWSSimplified

Preet Sharma

Problem Solver, Solutions Architect | Helping Organizations with Value-Innovation Solutions | C...

The Start





Biological Cell

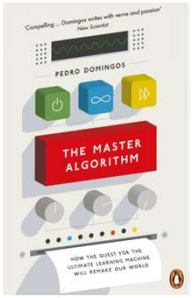
Survival

Immortal

Learn, Evolve and pass the learning

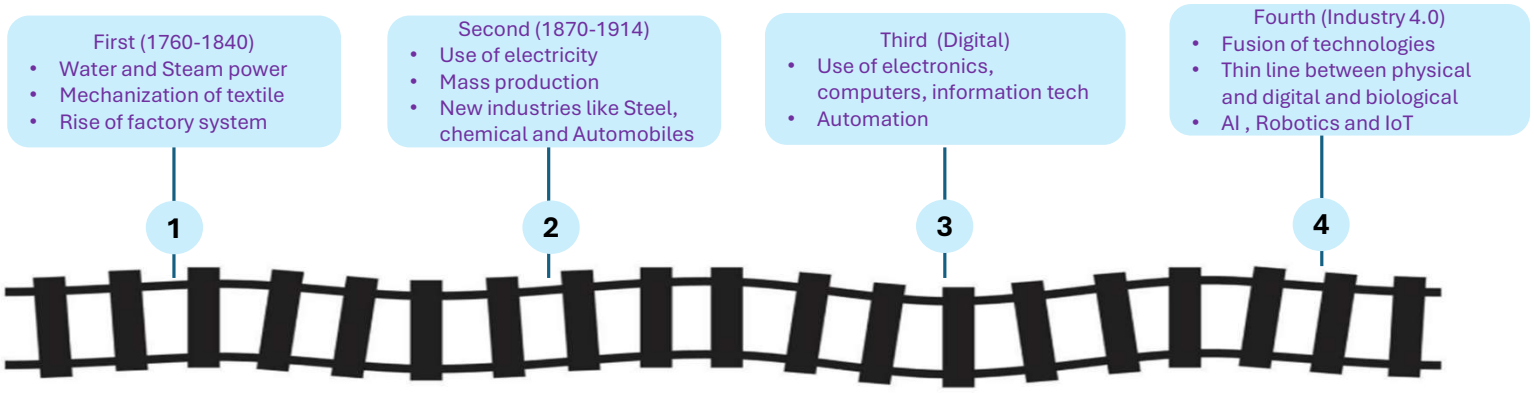
IQ

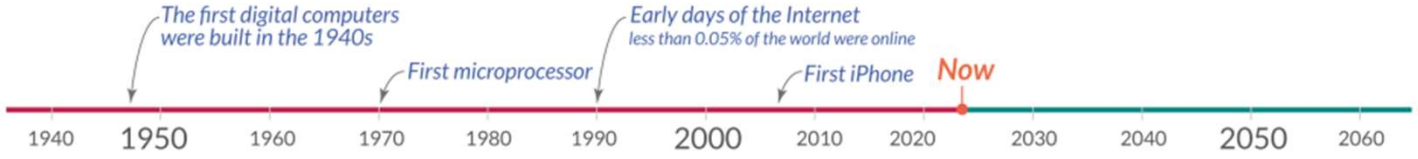
Reasoning Ability



Look at the history and world :

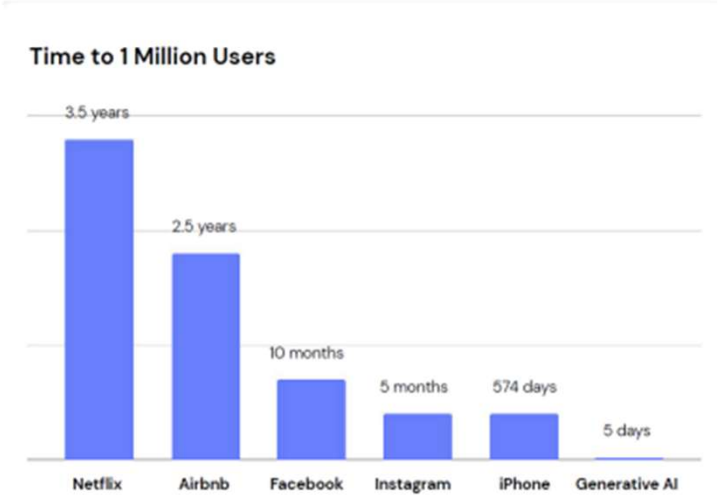
- **Industrial revolution**





The Tipping points

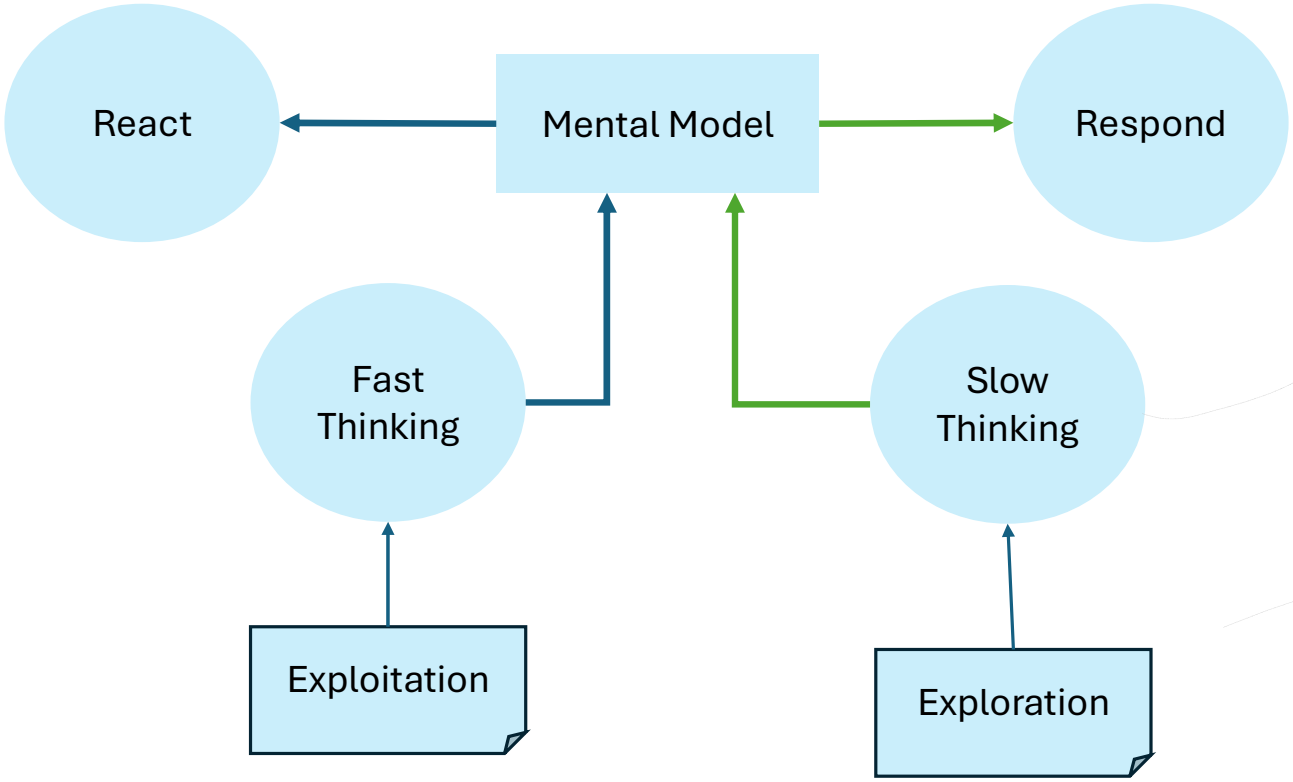
AI will result in the biggest productivity increase ever in history.

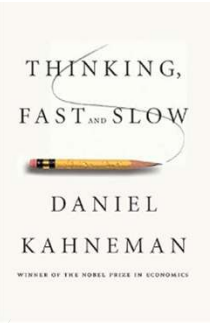


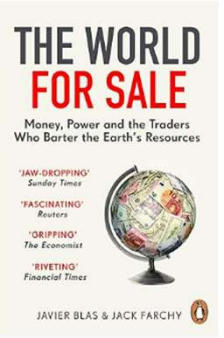
ChatGPT crossed the one million user mark in the just five days after it made public in November 2022

What is intelligence (ability)

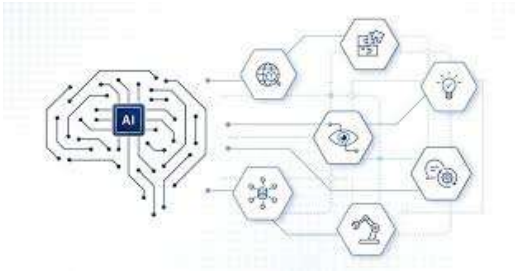
Acquires knowledge , Understand concepts, Solve problems, adapt to new unseen situations, and learn from experience.







Artificial intelligence



?

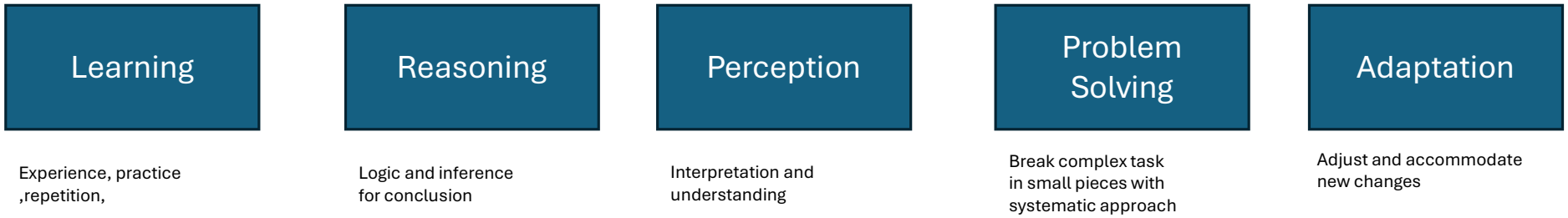
Describe AI in two words !

What is Artificial intelligence

Artificial Intelligence (AI) refers to the :

- Simulation of human intelligence in machines
- That can think and learn like humans
- Mimic like human
  - Visual perception
  - Speech recognition
  - Decision-making
  - Language translation
  - Process information
  - Recognize patterns
  - Solve problems

AI Characteristics



How to know a machine is intelligent ?

Intelligent
OR
Dumb

How to know a machine is intelligent ?

Turing Test

"if a machine can engage in conversations indistinguishable from those of a human"

Early Development
(1950-1960)

- Logic Theories: for mathematic operation
- General problem solver
- Eliza – Early stage chatbot

First AI winter
(1970-1980)

Struggle

- Computation
- Scaling simple demo
- Lack of data and power
- Overly optimistic prediction that failed

Expert Systems
(1980)

- Emulate decision making
- MYCIN : expert system to diagnose bacterial infection
- DENDRAL: identify molecule structure
- Expert system for computer configuration

Second AI winter
(Late 1980-1990)

Machine Learning
(1990-2000)

- Focus on Machine learning
- Statistical and Data driven approach rather than rule based
- Development of Support vector machine and other advance algorithms
- Increase of computational power
- Rise of the internet helped with vast data
- Success story like DeepBlue (Chess) motivated

Deep Learning Revolution
(2010-present)

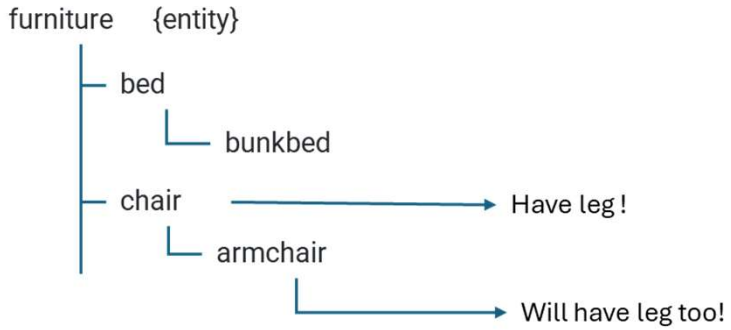
- Deep Learning breakthrough (neural network with multiple layers) in image recog , Natural language processing, Multi class Classification etc
- Explosion of Big Data for training , Computational power advancement (GPU,TPU, Cloud etc) , Open source framework

Landmark achievements:

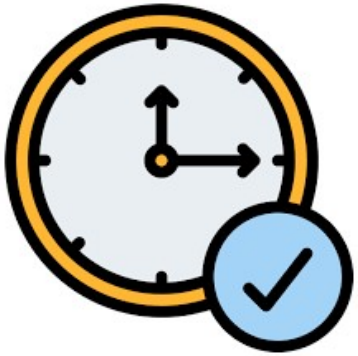
Wordnet

- Approximately 155,000 words organized into around 175,000 synonyms , >1.5 million semantic relations
- Largest lexical database in English for semantic network (conceptual semantic and lexical relation)
- Combines nouns, verbs, adjectives, and adverbs grouped together with cognitive synonyms
- Capture multiple types of relationship:

- Hierarchical relationship:
  - Hypernymy: is a relationship (dog-> mammals->animal)
  - Meronymy: Part-whole relationship(wheel->car, finger->hand)
- Equivalence relationship:
  - Synonymy: word with similar meaning (kitty , Young cat)
  - Antonymy: opposite meaning (Hot <-> Cold)
- Other relation
  - Entailment : for verbs (snoring -> sleeping)
  - Cause: casual relationship (kill -> die)
  - Similar to : near Synonyms



Time Check



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Landmark achievements:

Imagenet (2012)

- Started in 2006
- Reference from wordnet
- Large Visual Database of 14 millions images.
- Hand annotated in 2.5 years (Supervised)
- Annotation crowdsourced and verified 3 times
- 20,000 objects categories
- RGB Format

https://en.wikipedia.org/wiki/List_of_datasets_for_machine-learning_research

Average person recognizes roughly 30,000 different kinds of objects.

Landmark achievements:

IBM DeepBlue Chess (1997)

World Champion chess player Garry Kasparov was defeated by IBM's Deep Blue chessplaying computer in a six-game match in May, 1997.

- Enumerate & evaluate available strategies based on current world state and opponent play within rule constraints
- Computational brute force search over game tree to choose optimal move using sophisticated heuristics, evaluation functions.

https://www.computerhistory.org/chess/stl-431e1a07b22e1/

Google AlphaGO (2016)

- Supervised Learning (SL): a dataset of human games was used to teach the neural network to predict human moves.
- Reinforcement Learning (RL): the trained model played numerous games against itself. It utilized RL to continually improving its policy and value networks.
- Monte Carlo Tree Search (MCTS) for planning and exploring the game tree during decision-making

Landmark achievements:

AI Can listen ...and Talk

- Listen to, understand and respond to user commands with a voice-based interface.
- Automatic Speech Recognition (ASR) must handle various accents, dialects, and background noise
- Natural Language Understanding (NLU) involves processing user's intent, context, and entities mentioned in the conversation

- Real world issues include maintaining context over multiple turns, multi-modal interaction, user privacy, robustness to adversarial attacks, continuous learning and adaptation

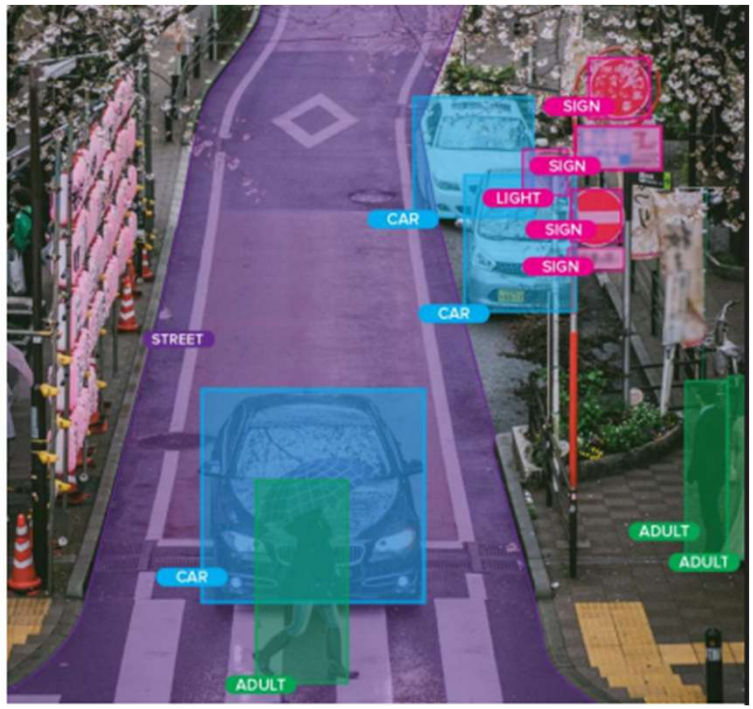
Landmark achievements:

AI Can See

- Assign descriptive text labels to different objects in an image
- Provide semantic information about image content
- Establish a relationships b/w visual features and text

Real world applications include

- identifying and tracking pedestrians, vehicles, and other objects in autonomous vehicles.
- annotating and categorizing medical images to facilitate the diagnosis and analysis of medical conditions
- identifying land use, vegetation, infrastructure etc. in satellite, drone images
- detecting and tracking people, vehicles, or unusual activities in real-time for security & surveillance
- identifying and filtering inappropriate or sensitive content for content moderation in social media

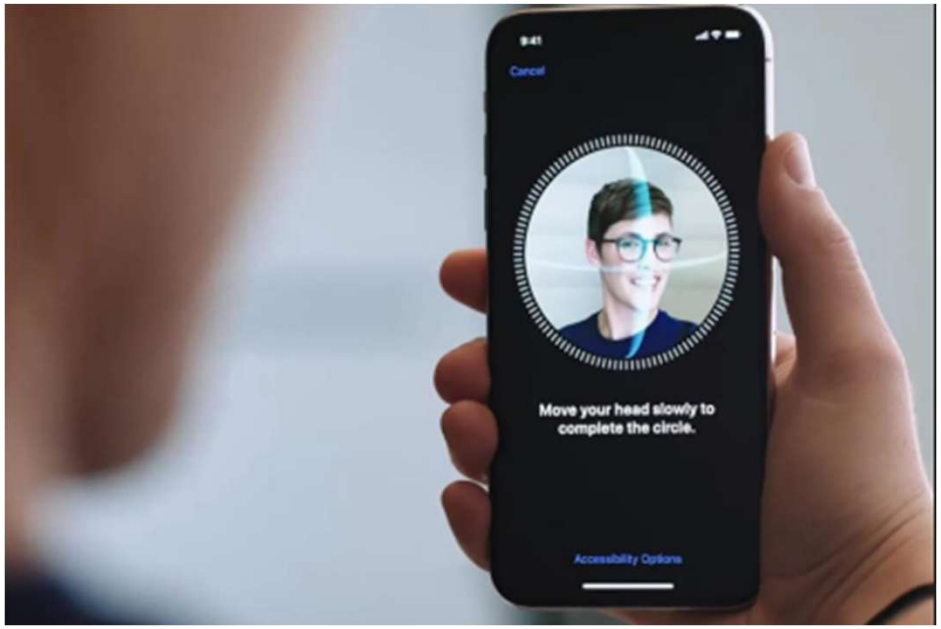


https://www.digitaldividedata.com/blog/autonomous-driving-global-movement

Landmark achievements:

AI Can Recognize

- See, detect and recognize human faces from an image, video.
- Computer Vision (CV) must handle varying camera qualities, low lighting conditions, dynamic camera angles, hand jitter etc.
- Deep Learning techniques like CNNs, Capsule Networks, Siamese Networks, DeepFace, and DeepID learn hierarchical features from facial images for accurate, robust identification.



Real world issues include

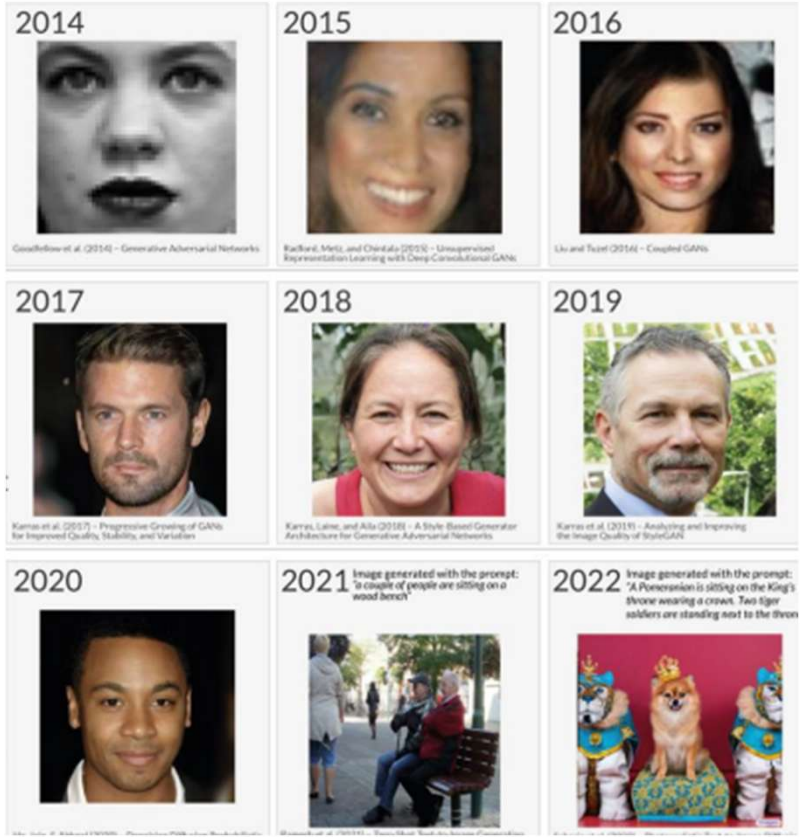
- accuracy & reliability across lighting conditions
- camera-distance
- race, gender
- Glasses
- make-up, hairstyle
- acceptable compute
- privacy.

Landmark achievements:

AI Can Generate Images

- Generating images from text involves employing deep learning techniques e.g. Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs).
- They map both textual descriptions and real images into a shared latent space, where the relationships between text descriptions and images are preserved
- Pre-trained models on large datasets can be fine-tuned on specific datasets for face generation tasks.
- For human faces (e.g.), these models learn to generate realistic faces by capturing patterns and features from datasets of human faces like CelebA, FFHQ (Flickr-Faces-HQ) etc

Timeline of images generated by AI (non real people)



Landmark achievements:

AI Can deceive

- Deepfakes are synthetic media (images/videos) created using deep learning techniques to manipulate or generate content.
- Typically involve the alteration or substitution of elements in existing media, often with a focus on human faces.
- Require a dataset of images or videos, typically containing target person's face from various angles, expressions, lighting conditions.
- Generative adversarial networks (GANs) are commonly used for deepfake creation. Generator creates fake images/videos, attempting to mimic real data Discriminator tries to distinguish between real and generated media.

Landmark achievements:

AI can drive

- Deep Learning for
  - object detection with models like DETR and YOLOv4
  - semantic segmentation with models like DeepLabv3
  - behavioral prediction of other agents in traffic with models like CARLA

- Reinforcement Learning for
  - decision-making, where the vehicle learns optimal actions through trial and error.

- Also uses Sensor fusion
  - combining camera, LiDAR
  - radar feeds to create a 3D map of the surroundings
  - detecting objects and assessing their velocity
  - Localization techniques combining GPS, IMUs and SLAM for precise vehicle positioning
  - PID* controllers and model predictive control algorithms for real-time control of the vehicle's movements.

*Proportional-Integral-Derivative

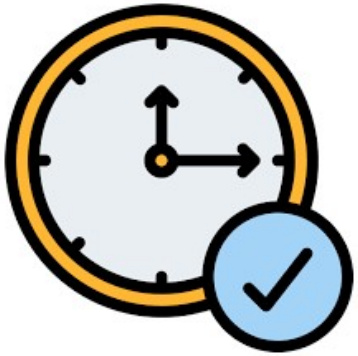
Landmark achievements:

AI can govern

- Discover tax policies in dynamic economies that can effectively trade-off economic equality and productivity.
- Use a two-level deep reinforcement learning approach to learn dynamic tax policies, based on economic simulations in which both agents and a government learn and adapt.
- A data-driven approach that does not make use of economic modelling assumptions and learns from observational data alone.
- AI-driven tax policies are effective when used in experiments with human participants.

https://blog.salesforceairesearch.com/the-ai-economist/

Time Check

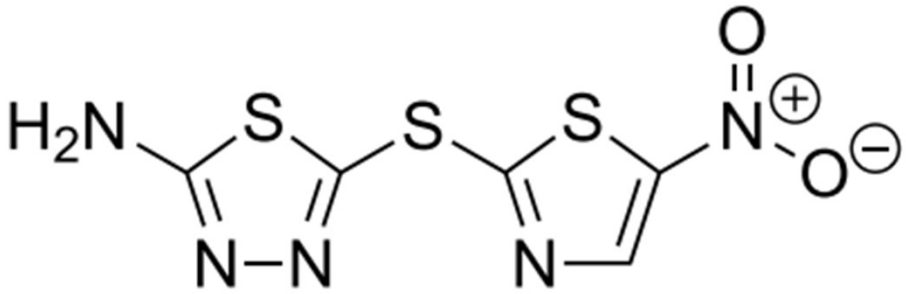


50%

Landmark achievements:

AI can discover the drugs (MIT Halicin (2019))

- Analyze large databases of chemical compounds, including existing drugs to predict their efficacy against multiple diseases.
- Useful for repurposing existing drugs for new applications as well as discovering new compounds likely to be effective.
- NLP to extract information from biomedical literature, patents, clinical trial data, aiding in the identification of potential drug candidates.
- GANs for generating novel molecular structures with desired properties. DL used for predicting molecular properties, analyzing protein-ligand interactions, and virtual screening.



- Halicin was originally developed as a potential treatment for diabetes. It was identified by AI as a likely broad-spectrum antibiotic.
- This likelihood was verified by in vitro cell culture testing, followed by in vivo tests in mice.
- It used an unusual mechanism of action - different from most antibiotics, it is effective against bacterial strains resistant to many commonly used drugs.

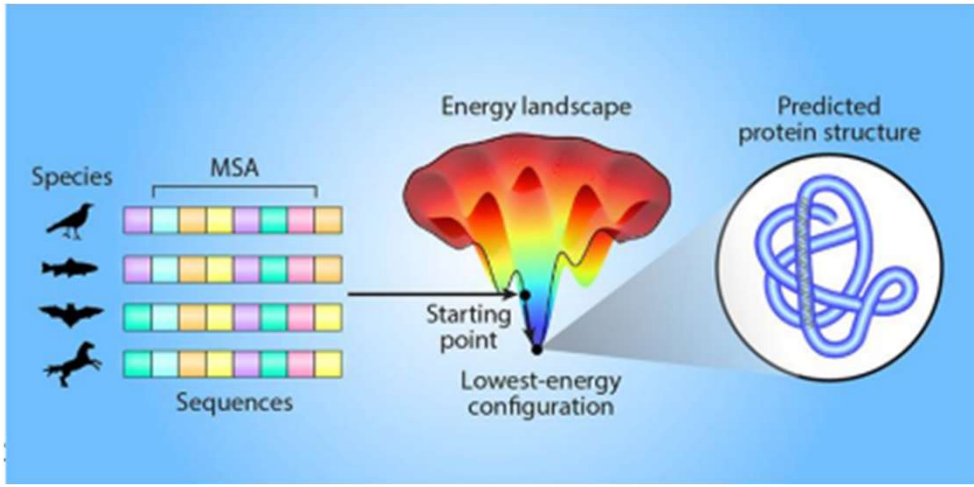
Landmark achievements:

AI can fold proteins (Google deepmind alphafold 2020)

- Predict the 3D folding structure that a protein will adopt based on its amino acid sequence.
    - Difficult because of the sheer number of ways in which the amino-acid sequence could fold
- Incorporates information from a diverse set of homologous protein sequences (related sequences found in different species)

- Uses DL with attention mechanisms to capture complex relationships within the protein sequences and to weigh the importance of different parts of the input sequence when making predictions.

- AI guides the understanding of physical processes too complex to be accurately modelled from first principles.



https://physics.aps.org/articles/v15/183

Landmark achievements:

AI can discover materials (Google deepmind GNoME 2023)

- AlphaFold for materials: Analyze combinations of elements in the periodic table, including existing materias to predict those with desirable properties

- Combines two different DL models.
  - M1 generates more than a billion structures by making modifications to elements in existing materials.
  - M2 predicts the stability (decomposition energy) of new materials purely on the basis of chemical formulas.

- GNoME has predicted structures for 2.2 million new materials.
- 700+ have gone on to be created in the lab and are now being tested.

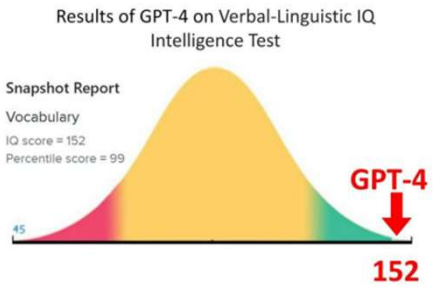
- Can help accelerate hardware innovation in energy, computing etc.

https://www.technologyreview.com/2023/11/29/1084061/deepmind-ai-tool-for-new-materials-discovery/

Landmark achievements:

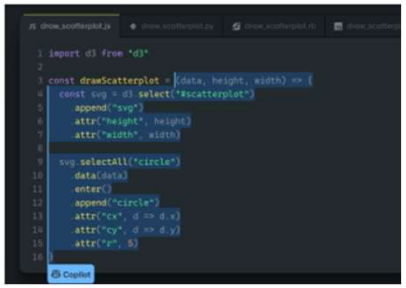
Last 2-3 years :

OpenAI ChatGPT (2022)
Google Bard (2023)



AI Can chat **“Intelligently”**

Github Co-Pilot (2022)



AI Can **“Code”**

Ikea + Space10 (2023)

AI Can **“Design”**

ABInBev Beck’s
Autonomous (2023)

AI Can **“Brew”**

AIsthetic Apparel CEO-
for-a-day (2023)

AI Can be a **“CEO”**

Many more.....

AI is all around us ...

AI Pricing

When you book a flight, the price you pay is determined by an AI algorithm

AI Security

At the airport, AI systems observe and monitory what you do

AI Co-Pilot

On the plane, AI systems assist pilots in flying planes

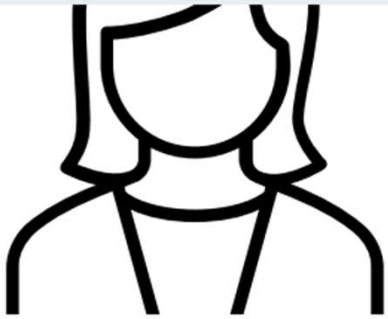
AI is all around us ...

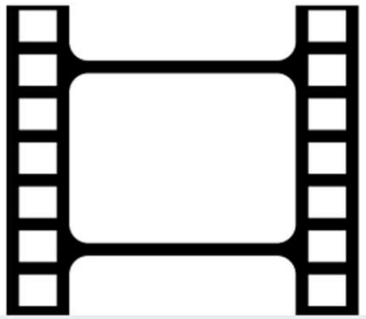
AI Loan

When you apply for a loan, AI systems decide whether or not you get a loan

AI Hiring

When you apply for a job, AI systems influence whether you get hired or not





AI Editor

When you scroll social media, AI algorithms determine which content you see next

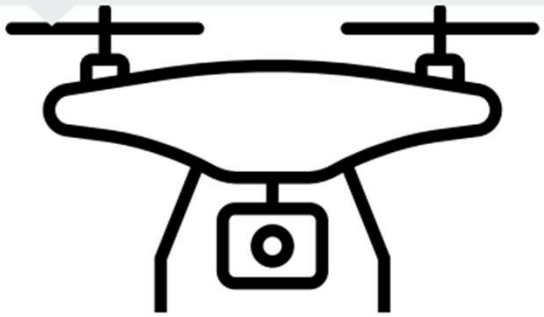
AI is all around us ...

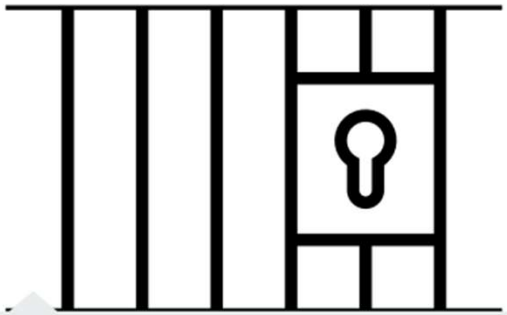
AI Cars

Self-Driving Cars are powered by AI

AI Weapons

Autonomous weapons are powered by AI





AI Jailer

AI algorithms are being used to decide who gets parole

How many types of AI do you know? Name them.

Types of AI

- **Artificial Narrow intelligence**

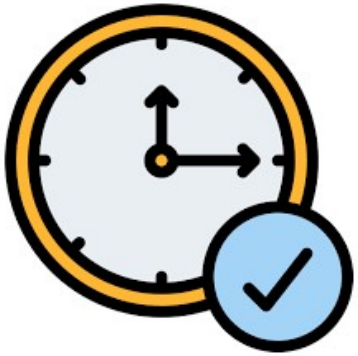
  “Specific task with limited domain”

  - Task-specific intelligence with high performance in designated areas
  - Unable to generalize beyond their training domain
  - Operates within predefined parameters and constraints
  - Represents the current state of most AI applications

Examples of Narrow AI

- **Image recognition** : identify objects, faces, or scenes in photographs with high accuracy but cannot perform language translation
- **Voice Assistants**: Siri, Alexa, Google Assistant can respond to voice commands but cannot drive a car
- **Game-Playing AI**: Chess engines like Stockfish or Go-playing systems like AlphaGo excel in their respective games but cannot play other games without retraining
- **Recommendation** : Netflix's content recommendations or Amazon's product suggestions work well for their specific platforms but cannot diagnose medical conditions
- **Autonomous Vehicles**: Self-driving car systems can navigate roads but cannot compose music or write poetry

Time Check



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Types of AI

- **Artificial General intelligence**

  "Human-level intelligence across multiple domains and can understand, learn, and apply knowledge in ways comparable to human cognitive abilities."

  - Human-level intelligence across diverse domains
  - Ability to transfer learning from one area to another
  - Flexible problem-solving capabilities
  - Self-awareness and consciousness (theoretical)
  - Ability to understand and generate creative content

Challenges of developing Artificial General Intelligence

- **Common Sense Reasoning:** Humans possess intuitive understanding of the world that is difficult to replicate in machines
- **Transfer Learning:** Creating systems that can apply knowledge from one domain to completely different areas
- **Consciousness and Self-Awareness:** Understanding and replicating the subjective aspects of human intelligence
- **Ethical and Safety Considerations:** Ensuring AGI systems align with human values and remain controllable

Types of AI

- **Artificial Super intelligence**

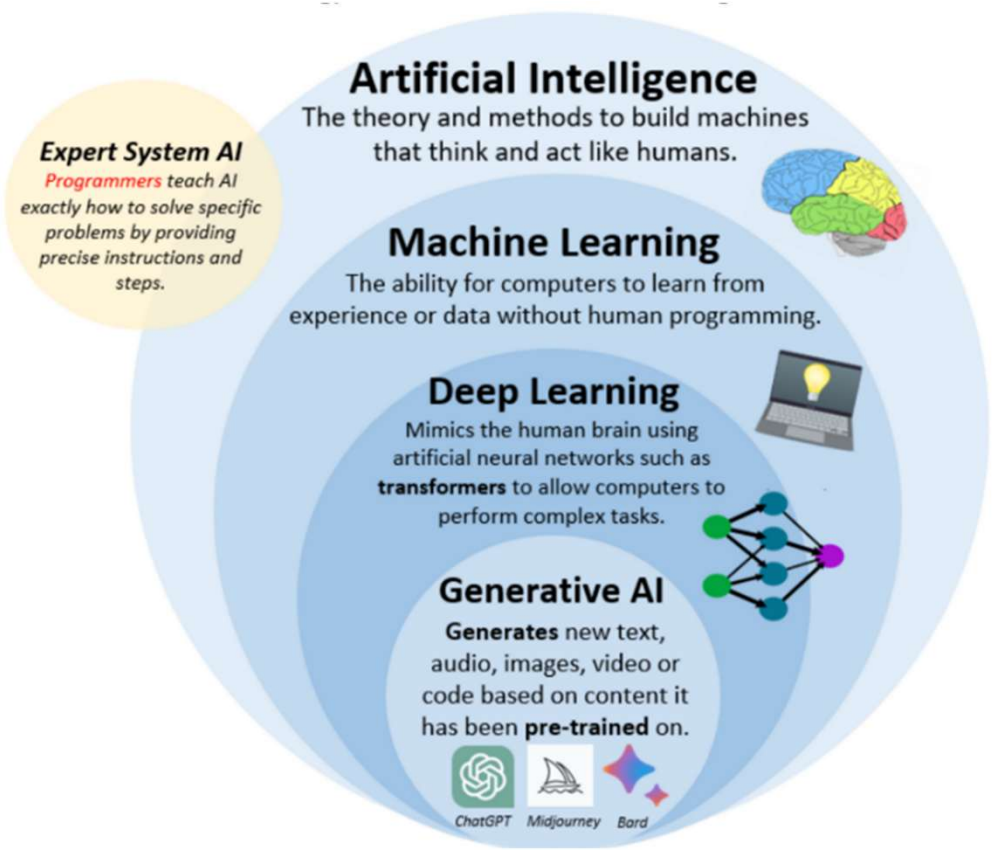
  "Super AI represents hypothetical AI systems that surpass human intelligence in all aspects, including creativity, problem-solving, and emotional intelligence."

  - Intelligence that exceeds the best human minds in every field
  - Capabilities far beyond current human understanding
  - Self-improvement abilities leading to rapid intelligence amplification
  - Potential to solve problems currently beyond human comprehension

Its only a Theory about "Artificial Super Intelligence"

- **Theoretical Implications:** Highly speculative. Always argue with doubt that ASI could lead to unprecedented benefits for humanity or existential risks if such systems are not properly controlled or aligned with human values.
- **The Intelligence Explosion Hypothesis:** Some theorists propose that once AGI is achieved, it could rapidly self-improve, leading to an "intelligence explosion" where AI capabilities grow exponentially, quickly surpassing human intelligence and leading to ASI.

AI vs Machine Learning vs Deep learning



Artificial Intelligence (AI)

AI is the broadest term for any technique that enables machines to mimic human intelligence. It includes both rule-based systems and learning-based systems. That Include**:**

- **Rule-Based Systems**: Expert systems that use predefined rules and logic
- **Search Algorithms**: Methods for finding solutions in problem spaces
- **Planning Systems**: AI that create sequences of actions to achieve goals
- **Knowledge Representation**: Ways of storing and utilizing information
- **Machine Learning**: Systems that improve through experience

AI vs Machine Learning vs Deep learning

Machine Learning (ML)

Subset of AI that focuses on algorithms that can learn and improve from data without being explicitly programmed for every scenario.

Key Concepts in Machine Learning:

- **Supervised Learning**: Algorithms learn from labeled training data to make predictions on new, unseen data. The system learns to map inputs to desired outputs based on example input-output pairs.
  Examples: Email spam detection, image classification, medical diagnosis
  - **Common algorithms**: Linear regression, decision trees, support vector machines, random forests

- **Unsupervised Learning**: Algorithms find hidden patterns in data without labeled. The system discovers structure in data where the desired output is unknown.
  Examples: Customer segmentation, anomaly detection, data compression
  - **Common algorithms**: K-means clustering, hierarchical clustering, principal component analysis

- **Reinforcement Learning**: learn through interaction with an environment, receiving rewards or penalties for actions taken.
  Examples: Game playing, robotics, autonomous vehicles, trading systems
  - **Common algorithms**: Q-learning, policy gradients, actor-critic methods

AI vs Machine Learning vs Deep learning

Deep Learning (DL)

subset of Machine Learning that uses artificial neural networks with multiple layers ("deep") to model and understand complex patterns in data.

- **Neural Network Fundamentals:** Neural networks are inspired by the structure of the human brain, consisting of interconnected nodes (neurons) that process and transmit information. Deep learning networks contain many layers of these neurons, allowing them to learn increasingly complex representations of data.

Key Architectures in Deep Learning:

- **Feedforward Neural Networks**: Information flows in one direction from input to output, suitable for basic classification and regression tasks.
- **Convolutional Neural Networks (CNNs)**: Specialized for processing grid-like data such as images, using convolutional layers that detect local features like edges and textures.
- **Recurrent Neural Networks (RNNs)**: Designed for sequential data, with connections that create loops allowing information to persist, suitable for language processing and time series analysis.
- **Long Short-Term Memory (LSTM) Networks**: A type of RNN that can learn long-term dependencies, addressing the vanishing gradient problem in traditional RNNs.
- **Transformer Networks**: Attention-based architectures that have revolutionized natural language processing, forming the basis for models like GPT and BERT.
- **Generative Adversarial Networks (GANs)**: Consist of two competing networks that learn to generate realistic synthetic data, widely used for image generation and data augmentation.

Real world application and impact

Healthcare and Medicine

AI is revolutionizing healthcare through improved diagnostics, treatment planning, and drug discovery.

- **Medical Imaging**: AI systems can analyze X-rays, MRIs, and CT scans with accuracy matching or exceeding human radiologists. Google's DeepMind has developed AI that can detect over 50 eye diseases, while IBM Watson for Oncology assists in cancer treatment recommendations.
- **Drug Discovery**: AI accelerates the identification of potential drug compounds, reducing the time and cost of pharmaceutical development. Companies like Atomwise use AI to predict molecular behavior and identify promising drug candidates.
- **Personalized Medicine**: AI analyzes genetic information, medical history, and lifestyle factors to create personalized treatment plans, improving outcomes and reducing adverse reactions.
- **Robotic Surgery**: AI-assisted surgical systems provide enhanced precision and minimally invasive procedures, with systems like the da Vinci Surgical System enabling complex operations through small incisions.

Real world application and impact

Transportation and Mobility

The transportation industry is being transformed by AI through autonomous vehicles, traffic optimization, and logistics management.

- **Autonomous Vehicles**: Self-driving cars use AI to perceive their environment, make real-time decisions, and navigate safely. Companies like Tesla, Waymo, and Uber are developing various levels of autonomous driving capabilities.
- **Traffic Management**: AI systems optimize traffic flow in cities, reducing congestion and emissions through intelligent traffic light control and route optimization.
- **Logistics and Supply Chain**: AI optimizes delivery routes, predicts demand, and manages inventory, with companies like Amazon using AI for warehouse automation and delivery optimization.
- **Predictive Maintenance**: Airlines and transportation companies use AI to predict when vehicles and infrastructure need maintenance, reducing downtime and improving safety.

Real world application and impact

Finance and Banking

AI has become integral to modern financial services, enhancing security, efficiency, and customer experience.

- **Fraud Detection**: AI systems analyze transaction patterns in real-time to identify suspicious activities and prevent fraudulent transactions, protecting both consumers and financial institutions.
- **Algorithmic Trading**: AI-powered trading systems can analyze market data and execute trades at speeds impossible for human traders, though this has also introduced new risks and regulatory challenges.
- **Credit Scoring**: AI improves credit assessment by analyzing diverse data sources beyond traditional credit history, potentially expanding access to financial services.
- **Robo-Advisors**: Automated investment platforms use AI to provide personalized investment advice and portfolio management at lower costs than traditional financial advisors.
- **Customer Service**: AI chatbots and virtual assistants handle routine banking inquiries, while natural language processing helps analyze customer feedback and improve services.

Real world application and impact

Retail and E-commerce

AI is reshaping how consumers shop and how businesses operate in the retail sector.

- **Dynamic Pricing**: AI algorithms adjust prices in real-time based on demand, competition, inventory levels, and customer behavior, optimizing revenue and competitiveness.
- **Inventory Management**: AI predicts demand patterns and optimizes inventory levels, reducing waste and ensuring product availability.
- **Customer Experience**: AI-powered chatbots provide customer support, while computer vision enables cashier-less stores like Amazon Go.
- **Supply Chain Optimization**: AI optimizes logistics, warehouse operations, and delivery routes, improving efficiency and reducing costs.

Education and Learning

AI is personalizing education and making learning more accessible and effective.

- **Personalized Learning**: AI systems adapt to individual learning styles and paces, providing customized educational experiences that can improve learning outcomes.
- **Intelligent Tutoring Systems**: AI tutors provide personalized instruction and feedback, available 24/7 to support student learning outside traditional classroom settings.
- **Administrative Automation**: AI streamlines administrative tasks like grading, scheduling, and student assessment, allowing educators to focus more on teaching.
- **Language Learning**: Apps like Duolingo use AI to personalize language learning experiences, adapting difficulty and content based on user progress and preferences.

It’s too BIG beyond our thinking…

- Be consistent in class
- Be interactive and vocal
- Be ready for hands-on exercises with massive data
- Be responsible with AI, “as great power comes with great responsibility”

"Let's grow together to make this world a more beautiful place to live for the human race with humanity."

AI Simplified # Chapter 2

#Artificial Narrow intelligence

RECAP : Artificial Narrow intelligence

Mathematics

- Vector and Vector spaces
- Vector Operations
- Matrix and matrix operations
- Single Value decomposition
- Probability and Statistics
- Random variable and distribution
- Concept of Hypothesis
- Information theory

Data

- Structure Data
- Semi structure data
- Text /Image/Video/Audio
- Data formats